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THE SIMPLICITY OF COLOR TONES.

By I. MADISON BENTLEY.

The existence of composite colors has long been a matter of dispute. Among psychologists, no less than among artists and the laity, the contention has frequently been made that red and blue are pure, elementary, unmixed colors while orange, yellow-green and purple are mixed, derivative, composite.¹ If we ask—not how a given color is produced, but—what one actually sees in a color—a single quality or a plurality of qualities—the problem becomes strictly psychological and must be worked out under psychological methods and in psychological terms. Let us see if the problem is soluble.

The place of any color whatsoever in the general scheme of visual qualities is determined by three factors; (1) color-tone (as red, greenish blue, violet), (2) brightness, *i. e.*, relation to black and white, and (3) saturation, *i. e.*, distance from gray of an equivalent brightness. Our special question arises in connection with the first factor; color-tone. Are all tones equally simple? or are some tones simple and others complex? Current color terms do not help us to decide. The names of many 'intermediate' colors suggest, it is true, a plurality of components; *e. g.*, 'yellow-green' and 'orange-red.' But we are not warranted in drawing the inference that these compound terms really cover mental complexes. And, moreover, the appeal to introspection has never been entirely satisfactory. Psychologists seem to be unable to agree on what they 'see' in the yellow-greens, the oranges and the purples; whether a single quality or more.

Look for a moment at the general system of color-tones, as arranged, let us say, around the base of the color-pyramid. The first thing that strikes one's notice is the presence of two

¹That the 'composite' theory has not lacked authoritative support is shown both by Hering's contention that yellow makes a much stronger impression of simplicity than does violet (*Ueber Newton's Gesetz der Farbenmischung*, 1887) and by Goethe's conviction,—a conviction that was shared by Sir David Brewster—that he actually 'saw' blue and yellow in green. (*v. H. Helmholtz, Physiol. Optik*, 2nd ed., 380.) Even Helmholtz, while he criticizes earlier writers for confusing mixed pigments and mixed colors, himself falls into the error of believing that nearly all colors are analyzable into simpler elements (*cf. Sensations of Tone*, 1895, 64).

major groups. The one contains the reds and the yellows; the other, the greens and the blues. Within each group there is a special kinship that marks off the one group from the other. Within each group, again, we find two minor groups each of which forms a qualitative continuum. Toward the ends of each major group lie parts of other continua which are completed by joining these groups at both ends (Y to G and B to R). Thus we have four continua, R to Y, Y to G, G to B and B to R. Each continuum is comparable, introspectively, with the black-white series. These qualitative continua differ from intensive series in that they lie between unlike qualities instead of between zero and a maximal value. In a 'perfect' intensive series, there is no qualitative change and no fusion of intensities—only variations in distance from zero; in a 'perfect' qualitative series there is only qualitative change—neither change of intensity nor admixture of unlike qualities. Such a perfect series of the latter type may be represented by the tonal continuum.¹ In this series, all members are equally simple. No tone contains a lower and a higher; although a pitch is more *like* its near than its remote neighbors. Introspection on this point is unambiguous. But are the color continua such 'perfect' qualitative series? This is the crux. Intensive differences among the visual qualities offer no difficulty. They may be ruled out. The difficulty lies in the alleged complexity of the 'intermediate' colors. Does an orange 'contain' both red and yellow? If it does, can it be factored into a red and a yellow? or is 'orangeness' left over from the analysis? The facts of color mixture must not be adduced as argument. Of course, O is 'produced' by mixing R and Y; but this fact is irrelevant.² Nevertheless there does seem to be an introspective difference between orange and yellow or orange and red. Two points must, I think, be conceded to the complexity argument. First, there is a peculiarity about the four qualities, R, Y, G, B.; and, secondly, all other tones 'look like' some one pair of these. The peculiarity consists in the fact set forth above; the fact that these four qualities are the natural termini of the four continua. Black and white are peculiar in the same way. We can even conceive that black should be the initial member of two continua (instead of one) as R is. In regard

¹The fact that a constant physical intensity does not give a constant mental intensity is not important.

²I have been at some pains to question artists on their distinction between simple and compound colors. From their own introspective accounts and from the fact that they class green with the compounds, I conclude that the distinction rests solely on the method of pigment-mixtures. Blue is a 'pure' color because it is produced by a pure pigment; green is compound because it is made by the mixture of yellow and blue pigments.

to the second point, the likeness of intermediates to termini is not a valid argument for the complexity of the intermediates. For (a) orange is 'like'—let us say—twelve other qualities, orange-reds and orange-yellows; but it would be absurd to contend that orange is composed of twelve elements or that its elements are indeterminate. Again, (b) any one of the termini, *e. g.*, red, is 'like' a score of oranges and purples, but the argument from similarity deftly avoids the implication that red is compound.¹ Finally, (c) the similarity argument would forever debar science from having 'elements,' since it is impossible to find anything so simple that it is unlike everything else in the world.

What support is left, then, for the alleged complexity of the intermediate colors? There is left the argument that the color system presents four color types which, however we combine them, are never augmented. We get always combinations; never new types. This is a fair psychological argument and must be taken account of. But though it is true that we never get new types, it does not follow that we get no new color qualities.

Granting this, however, it may be answered that the new colors are fusions of the old and, therefore, complex. This brings us face to face with the ultimate question of the criterion for elementariness. Elementariness may be either psychological or psychophysical. A psychophysical criterion would give us, in this case, either simplicity or complexity according as we maintained allegiance to one theory of visual sensations or another. The Helmholtz theory, *e. g.*, would make every visual quality complex as depending upon a plurality of nervous structures. The Hering theory has four primary colors (if we leave out black and white), each of which depends upon a specific function or a specific structure. For the mediation of all other color-tones, more than a single type of struction is required.² Psychological criteria of simplicity are often difficult to apply; but they are vastly to be preferred, within psychology, over psychophysical criteria. One analyzes introspectively so long as one can think a quality or a group of qualities as exist-

¹The argument from similarity is stated thus by Stout. "The respect in which blue and blue-green are seen to resemble each other when compared is different from the respect in which green and blue-green resemble each other when compared. This appears to me a sufficient reason for inferring complexity in the blue-green." (Manual, 149.) But the argument works as well for blue compared, on the one hand, with blue-green, and, on the other, with violet or for red compared with purple and with orange.

²If the simplicity of all color-tones be admitted, the stock argument against the Hering theory for selecting a *bluish* green for its Ugruen and a *purplish* red for its Urroth loses its strongest support.

ing apart from its context. When the element is reached, the object of attention refuses to be thought further as object and context. Attention is no longer able to pass from point to point without apprehending material already separated off. Take the sensation purple. Does one get the element red within the purple? or does one pass beyond the purple and institute a comparison of similarity between the purple and some imaged or observed red? The latter, surely.

But, it may be answered, to compare the two qualities and to judge them similar is precisely the necessary first step in analysis. A mental complex is dissected it may be urged, by determining its likeness to a plurality of other contents. This view of analysis is current in the literature. It can, however, be said that comparison leads invariably to analysis only on the assumption that similars are always complexes, possessing identical parts. But this assumption leads to a logical absurdity. If elementary things are, in no sense, alike, they cannot be compared; cannot, therefore, be considered even different, neither can they be brought together into a system. No: comparison is essential to *classification*—the relative positions of red, blue and purple in the system of color qualities, *e. g.*, is determined by comparison—but classification and *analysis* are quite different processes and yield wholly unlike results.

Thus we see that the arguments both from the four visual types and from the twofold resemblance of the intermediate colors are insufficient to prove the complexity of visual qualities; while we find ample grounds for the belief that one color-tone is as simple and as ultimate as another. At the same time, it would be difficult to find a more illuminating instance of the essential difference between psychophysical and psychological problem and of the necessity for distinguishing mental analysis from the objective simplification of physical and physiological factors.